

GEOLOGY

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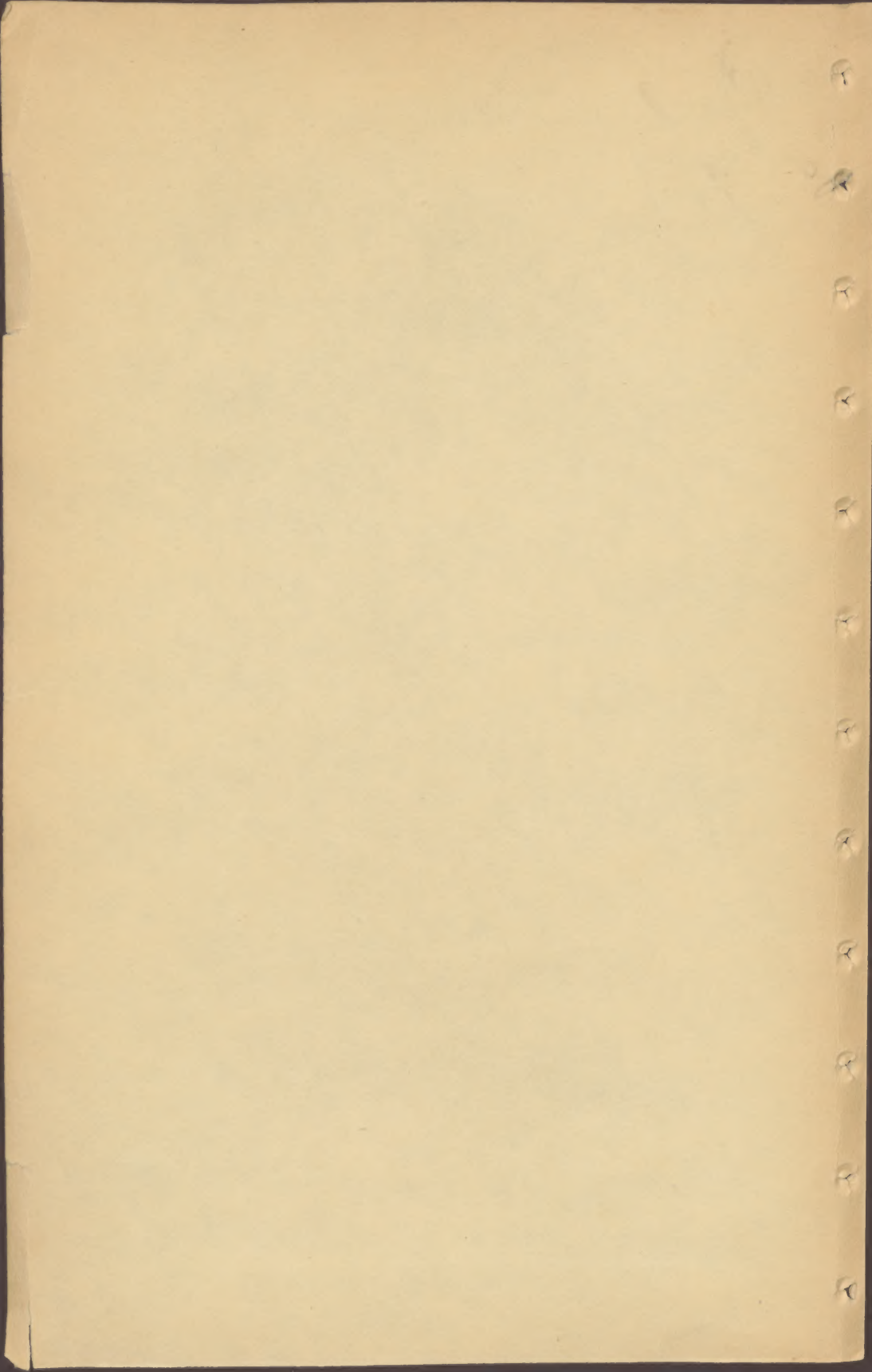
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NAVASSA.

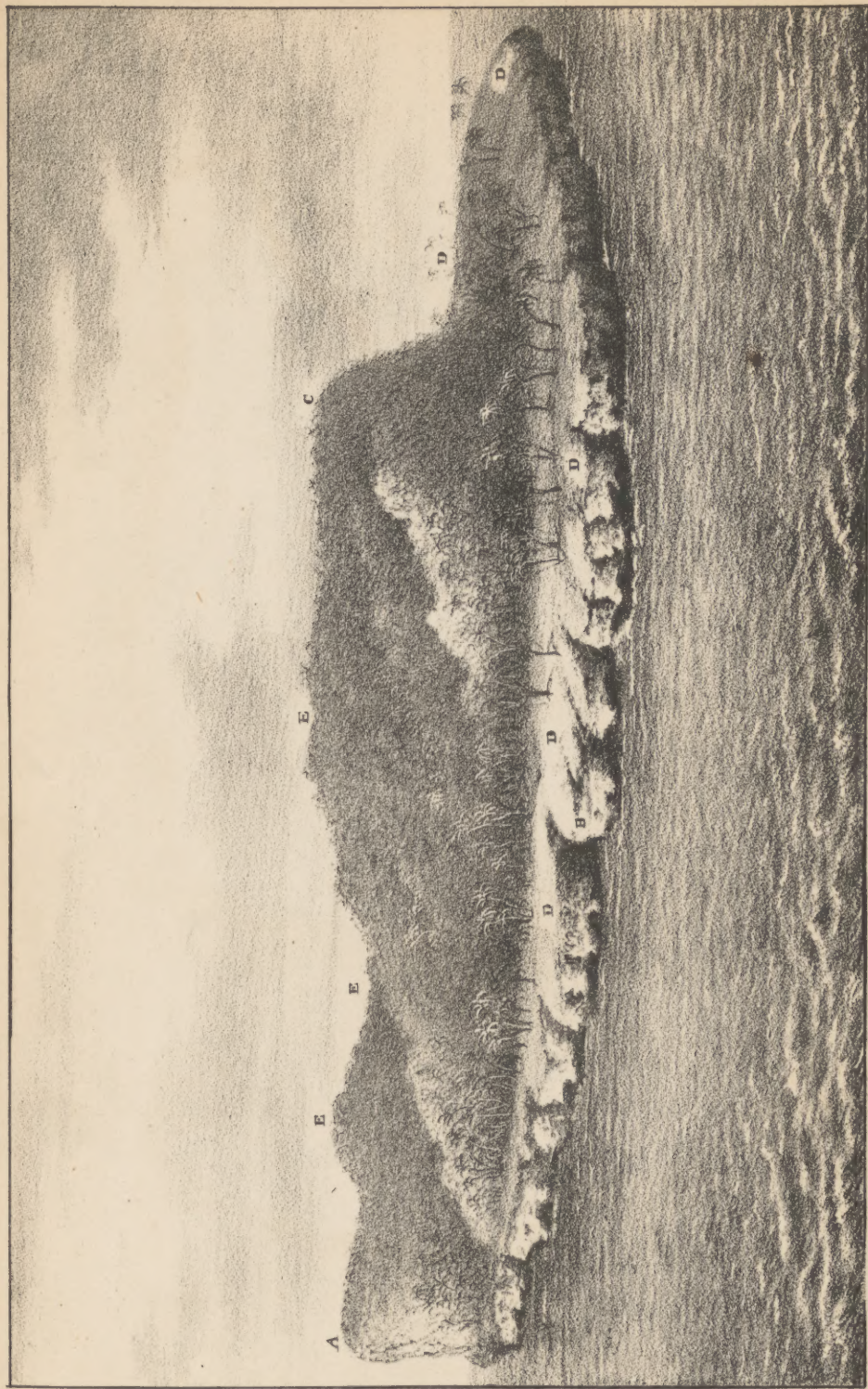
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U.S. Geol. Surv. Photo No. 105

A. North Point 350 feet high.
 B. Lulu Bay Cliffs 30 feet high, perpendicular.
 C. South East Point 350 feet high.

NAVASSA ISLAND.

D. Newly discovered deposit of rich phosphate averaging from 65 to 77% bone phosphate.
 E. First discovered phosphate.

NAVASSA PHOSPHATE COMPANY.

Incorporated under the Laws of the State of New York,

PURSUANT TO THE PROVISIONS OF AN ACT PASSED FEBRUARY 17, 1848,
AND THE SEVERAL ACTS IN ADDITION THERETO,
AND AMENDATORY THEREOF.

CAPITAL 30,000 SHARES.

Par Value of Shares \$100 Each.

OFFICES:

81 JOHN STREET, NEW YORK.
32 SOUTH STREET, BALTIMORE.

DEPOT AND MILLS, PATTERSON'S WHARF, BALTIMORE.

September, 1864.

1877

Dec 1877
M 22

OFFICERS.

1864—1865.

President :

HON. SAMUEL GREENE ARNOLD.

Vice Presidents :

WILLIAM BELL,
JOHN C. GRAFFLIN.

Treasurer:

WALTER E. LAWTON.

Secretary:

JAMES PARRY DAVIES.

Counsel:

JOHN S. WOODWARD, NEW YORK.
T. S. ALEXANDER, BALTIMORE.

Superintendent at Navassa:

A. E. SMYRK.

Executive Committee:

J. C. GRAFFLIN, E. K. COOPER, W. E. LAWTON.

Agent :

R. W. L. RASIN, 32 South Street, Baltimore.

fertilizers ; our inability to collect a sufficiency of stable manure, and the almost exhausted state of the localities of the above named phosphates, have rendered most opportune the discovery of an immense formation of mineral phosphate for the daily increasing manufacture of fertilizers, which scarcely covers the demand.

Of the history of Navassa not much can be said, as only traces were found, to indicate that it, at one time, offered a temporary abode to some Indian tribe. In the year 1856, Captain E. K. Cooper discovered the island, and has since been in the indisputed possession of it.

Situated in $18^{\circ} 25'$ north latitude, and $75^{\circ} 5'$ west of Greenwich, south-west of St. Domingo and east of Jamaica, it presents itself, seen from the windward, as a perpendicular rocky mass of about three miles in length, rising some three hundred feet above the level of the sea. Its base widens to the south-west, and extends from south to north-east to a low flat level, which, almost a plain, stretches in its southern extremity about one mile out into the ocean. The whole of the island is, with little exception, covered with a luxuriant vegetation of dense woods and grass. Different species of the palm tribe, viz: Sabal Palmetto, Areca oleracea, etc. : several varieties of Cactus, some of immense sizes—vines and other climbing plants, give the whole the character of a true tropical landscape.

The island is inhabited by about forty white men, who, under the management of Captain Louis, work the place, and are provided with all the necessary accommodations.

The rock, which constitutes the island, is a hard white globuliforme limestone, which, from the numerous fossiles found in it, is evidently a Jurassic limestone. It is full of cliffs and fissures and interstratified with numerous layers of phosphate of lime, the out-croppings of which, on all parts of the island, make such splendid show, that even a casual observer cannot fail to disclose the fact of an almost inexhaustible deposit of this mineral. The strata and layers, the exact number of which, on account of only parts of the island being cleared of the wood, could not be ascertained, vary in thickness and their physical properties, hardness, specific gravity and color, (from the light yellow to the dark brown,) and differ consequently in their chemical constitution.

Under the lens, this mineral appears as a conglomerate of round globules of phosphate of lime, coated with a thin crust of oxide of iron and imbedded in a solid mass, which, in the darker specimens consists also of phosphate of lime.

The analysis below, made of samples of different colors, which I collected myself, will show, that this mineral, whilst it contains a uniformly high per centage of phosphoric acid, is in some parts of the island richer in phosphate of lime than in others, where the amount of phosphate of iron and alumina is larger than in the former.

The richest specimens being obtained from below the surface, demonstrate that it improves with the depth.

Again, there are some layers which have a bright rusty color, rough texture and are very friable. In these the globules are not so close together, and the mass in which they are imbedded is almost pure oxide of iron.

These exposed for thousands of years, as they undoubtedly have been, to the atmospheric action, rain, etc., became disintegrated and loose, have gradually filled the cavities of the limestone rock, and thus formed the soft deposit, with which the upper flat of the island, some one thousand acres, is covered.

From this loose mass the first shipments into the Baltimore market were made. It was introduced under the name of Navassa Guano—as such it was known, until Dr. Campbell Morphit, in his treatise on the different Guanos, (see *American Farmer*, Vol. II, No. IV,) pronounced it for the first time to be a mineral phosphate. It is a more or less coarse powder, of a rusty color, and otherwise well enough known at present, as to need further description.

This deposit, of which about four to five thousand tons are dug and ready for shipment, is, as seen by the analysis, the most inferior found on the island, but, I am glad to say, it forms also the smaller portion to be worked. By a proper process, however, it can be improved, raised to 64-65 per cent. of phosphate of lime, and thus made marketable, if desired.

While speaking of this upperland, I cannot neglect to mention the existence of a number of caves there of various sizes, the bottoms of which are covered with a fine grayish looking substance, widely different in its character from the other de-

posits. It is very soft, sparingly mixed with globular grains, and yields a high amount of phosphate of lime with some magnesia phosphate. As it contains perceptible traces of nitrogenous organic matter, it seems to be of animal origin, similar to that of Mexican Guano. A sample representing a pile of twenty tons, collected in a cave of about 10' length, which I visited myself, shows almost 70 per cent. of lime-phosphate, thus proving it to be a valuable article worthy of consideration.

The lower flat land, which is by far the largest of the two, covering scarcely less than two thousand acres, is the great depot to which I wish to call your attention.

Being accessible with but little outlay of capital, and furnishing at a low calculation one thousand tons to the acre, it will constitute, independent of the rocky phosphate, for a great number of years the main source of supply for the trade.

This deposit, the product of disintegration of the richer layers, has the same globular formation, but the globules are larger, the coating is thinner and consists of alumina with some silicates. It is of light brown color and analyses from 62 to 72 per cent. of phosphate of lime, and will be a desirable material for the manufacturer.

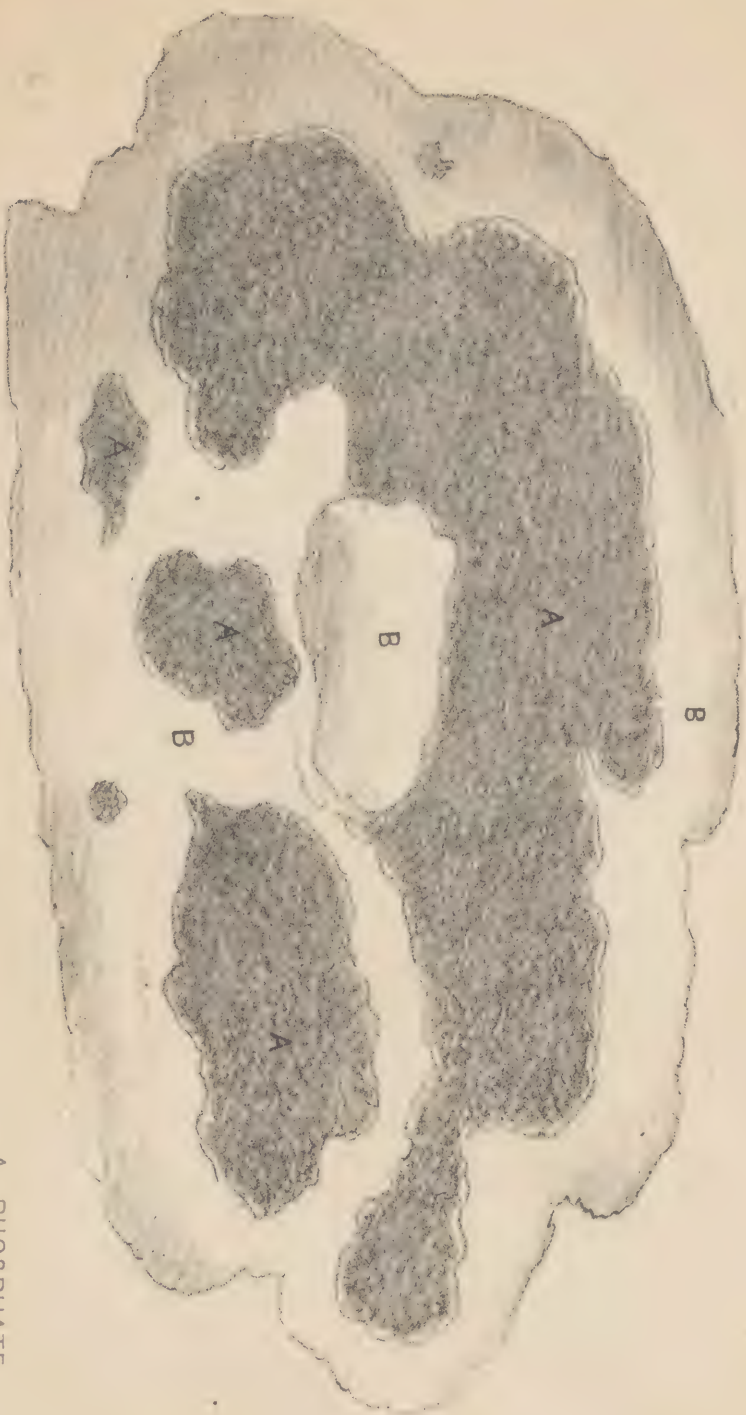
From the peculiar formation, and the presence of free oxide of iron, it is fair to suppose that the phosphate of lime of the Navassa Island, originated from phosphate of iron and alumina, which alternating with strata of limestone, were gradually transformed into phosphate of lime. This supposition is corroborated by the large quantity of oxide of iron which is found in many places of the island, and had been set free during the process of transformation by the lime of the limestone.

I have to express here the regret, that during my exploration of the island, I did not find any crystals of this phosphate, as from my analysis I am strongly inclined to consider it a new mineral, which I should propose to call "Navassite," if my suppositions were confirmed by subsequent examinations of the chemical and crystallographic characters of more perfect specimens.

But if I have to leave for the present this question of scientific interest without solution, I am happy to record here the discovery, I may say, of an inexhaustible quantity of a mineral substance, the phosphate of lime, so instrumental in the development of agricultural wealth.

S. N. H. C.

W



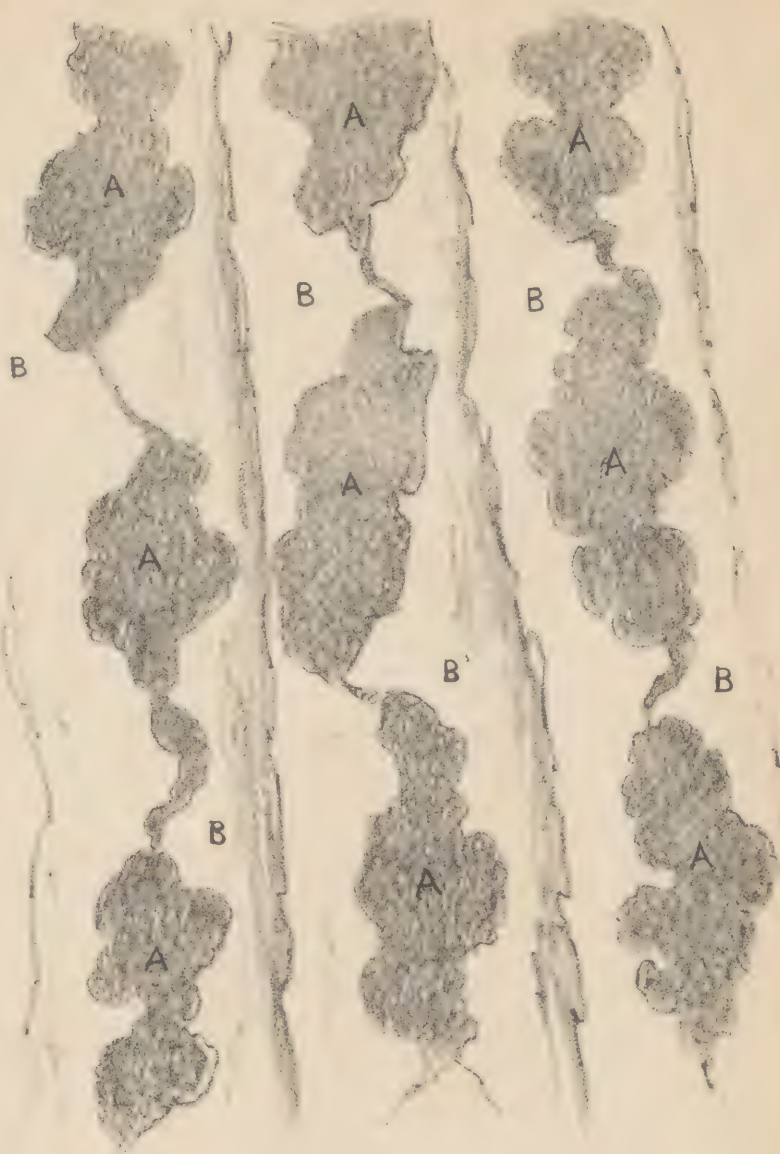
S. N. 10 feet,
E. W. 6 feet.

E.

A. PHOSPHATE.
B. LIMESTONE.

SURFACE VIEW OF PORTIONS OF A FIELD OF PHOSPHATE

Sketch D



VERTICAL SECTION OF PHOSPHATIC DEPOSITS
IMBEDDED IN LIME STONE

A. Phosphate

B. Limestone

The fact that phosphoric acid is an indispensable agent to the maintainance of vegetable life and the formation of grain, becoming daily more understood by the farmer, I think it needless to dwell further on this subject, or to speak of the benefit derived from the application of phosphatic manures.

There were a variety of artificial manures introduced into the market, each of which was claimed to be the most effective one.

The enormous success, however, attained by the use of dissolved phosphate or super-phosphate of lime, attributable to the solubility of portions of its phosphoric acid, soon established the character of its superiority, and has elicited the establishment of extensive factories for this class of fertilizers.

The importance of your discovery will be readily understood, from the fact that native phosphate of lime is of rare occurrence, mainly found in Spain and some few other localities, in deposits not large enough to be the object of distant commerce. Found some years ago in the formation of crag and green sandstone of England, its extraction was expensive, and thus the manufacture of the most desirable fertilizer, the super-phosphate of lime, was wanting a source of abundant supply of the main material.

This substance, in future and for a long time to come, will be supplied to the trade to the extent of its demands, without other limits but the labor on the island and the shipping facilities.

Before closing this report, I have to insist on this most important fact, that the phosphate found on the Island of Navassa is a mineral and not a guano, although known since its introduction into this market as Navassa Guano.

From their nature, the deposits of guano are limited, and their rapid exhaustion is already felt by the consumer, but the large development of phosphate of lime—a mineral substance—found on the Island of Navassa, gives the assurance of a permanent and rich yield. As a fertilizer, the action of the ammoniacal guano is mainly due, besides to its contents of phosphates, to the proportion, or the elements it contains for the formation of ammonia. The sources for this agent are numerous, and may be supplied to the wants of agriculture by many varieties of manure, blood, flesh, fish, etc., but the case is not

the same with phosphoric acid, and from this fact, your property, the Island of Navassa, acquires a value that can hardly be exaggerated, and the working of it on the largest possible scale, will be the source of considerable and most legitimate profits.

G. A. LIEBIG.

ANALYSIS.

I. LOOSE DEPOSITS.

A. LOWER FLAT.

	<i>Phosphate of Lime.</i>	<i>Phosphate of Iron and Al.</i>	<i>Phosph. Acid in toto.</i>
Lulu Bay.....	63.47.....	Not determined.....	Not Determined.
“ “	62.37.....	“	30.11
East of Lulu Bay.....	72.26.....	“	36.94
“ “	71.22	“	34.10
South and Southeast.....	61.46.....	“	Not Determined.
“ “	73.05.....	“	“
East of Island.....	58.35.....	“	33.80
“ “	63.58.....	“	33.94
North Crust.....	77.71.....	“	Not Determined.
“	69.27.....	“	32.65

B. UPPER FLAT—RUST LOOKING.

Surface..	64.77.....	5.06	Not Determined.
Fine.....	50.63.....	8.22	“
“	57.11.....	6.44	“
Cave contents	Gray colored.		
	69.36.....	Not determined.....	Not Determined.
	68.55.....	5.55	“

II. LAYERS AND BOULDERS.

Light Yellow Color.....	32.55.....	9.64	Not determined.
Yellow	56.11.....	Not Determined.....	34.53
Brown.....	71.75.....	5.11	34.41
“	71.55.....	8.55	36.51
Blasted 4 feet below.....	75.66.....	Not Determined.....	Not Determined.

P. S.—Some varieties of the native phosphate of lime resist with great force the dissolving action of Sulphuric acid, thereby impeding the process of manufacture of super-phosphate of lime. I have made several experiments to that effect with the Navassa-phosphate, and found that it offers no difficulty in successfully converting it into super-phosphate—samples of which contained from 10 to 15.5 per cent. of soluble phosphoric acid.

G. A. LIEBIG.

REPORT

ON THE

Phosphatic Mineral of Navassa Island, W. I.

♦♦♦

To the Corporation of the Navassa Phosphate Co.

SIRS :

The undersigned sailed for the Island of Navassa in June last to make a minute examination of its geological formation with especial relation to the mineral phosphates found on it, and has now the pleasure of making the following report :

Geographical Position and Features of the Island.

Navassa is situated in latitude $18^{\circ} 25'$ north, and $75^{\circ} 5'$ west of Greenwich, between the islands of Hayti on the east and Jamaica on the west, in the channel called the "Windward Passage," and distant from New York 1,300 miles.

It is $4\frac{1}{2}$ miles in length from N. E. to S. W., and its greatest width $2\frac{1}{2}$ miles. The north end being the narrowest point it presents the shape of a pear. It has two levels or flats—a lower one rising from 12 to 80 feet above the sea, and an upper one of 300 feet above it. The former begins about a half a mile west of the northern end, and widening more and more towards Lulu Bay, S. W., becomes beyond that point almost a perfectly level plain, covering, at a fair estimate, an area of 2,000 acres. This plain stretches around the south end, and continues on for more than a mile on the northeast side, until it is cut off by barren white limestone rocks. Near (south) Lulu Bay, a limestone reef traverses the lower flat, thus dividing it in two. The more southern one contains by far the greatest number of acres.

The upper flat is divided by reefs, or rather elevated limestone strata, (resembling, on account of their sharp pointed and perforated structure, coral reefs,) into several level fields, as can be seen by the Map B, representing the surface of the

island. It covers 1,000 acres, of which about forty have been worked, yielding from forty to forty-five thousand tons of phosphate of lime.

The water close to the shore is very bold, twelve fathoms deep, excepting a point near the western extremity, where a coral reef shoots out to the westward about one hundred and fifty feet, on which the depth of water is but twenty-seven feet, with fifteen fathoms all around it. The greater part of Navassa is densely wooded by palm trees and shrubbery common to the tropics. Large flocks of sea birds of various kinds roost on the trees of the lower part of the island, but their excrements are hardly perceptible. The climate is perfectly healthy; sea breezes moderate the tropical heat, so that even white labor can be employed without injury to health.

The only unfavorable feature of Navassa is the entire absence of springs. All the water necessary is either obtained from rains saved in cisterns, or has to be obtained from the near islands or the States.

Geological Formation.

The great progress made of late years in the science of geology, has made us so well acquainted with all the rock formations, that it is now a comparatively easy matter to determine and classify the different strata and place them where they belong.

Among the many petrified shells covering the joints of the limestone, the best preserved are *Pecten Personatus*, (the inner side of them,) *Gryphaea Virgula* and *Ammonites Striatulus*, in every respect like those so frequently met with in the Jura system of Europe. The limestone of Navassa belongs therefore to the secondary formation. It is of white color, has an uneven, rough fracture, enclosing some round grains (oolites) and apparently a great many small shells that cannot now be classed.

This island was, at the time of its origin, under the level of the sea, where the stratas were successively deposited in a more or less horizontal position. After a stratum of the compact limestone had been formed, layers of phosphate of alumina, phosphate of lime and globular lime, alternately changing with another, settled on it, being followed again by a stratum

of the former. This process has no doubt been going on for many ages, as the great number of strata of which the Island is composed demonstrate--as they stand now quite perpendicular, it is further evident that they were afterwards upheaved by plutonic power. Their strike is S. to N., possessing a thickness that varies very much. The strangest appearance in the white limestone are the round holes, from $\frac{1}{2}$ of an inch to 6 and 8 inches in diameter, produced probably from the emanation of gases. The sides of these holes, as well as those of the phosphatic beds, are covered with a crust of pure phosphate of lime, reaching a thickness of over half an inch.

The rocky kind of phosphate contains a few grains of yellow and blackish sand, but no remains of fossils of any kind are perceptible, having doubtless been destroyed by the action of the heat that existed at the time of the upheaval.

On the out-croppings of the limestone strata, the phosphatic minerals appear in nests of very irregular forms and sizes, as shown by sketch C. The greater part of them widen considerably in descending, and are finally cut out. See sketch D. I am, however, of opinion that, by removing the limestone intervening, similar nests will be found underneath, as it must be taken for a certainty, that the phosphate of lime running parallel with the strata of the carbonate of lime, will extend as far as the latter, a presumption partly proved, at a point right close to the level of the sea, on the N. W. side of the island, where the surf has washed away a part of the limestone and exposed a large stratum of rich phosphate, at a distance of over 250 feet from the top of the island.

On the lower flat the greyish phosphate is predominant; on the upper one the reddish brown. At innumerable places the hard undecomposed phosphate of lime crops out, from which, as well as from the fine, samples have been taken indiscriminately by Doctor Liebig, for the purpose of obtaining perfect and correct average ones.

Working of the Phosphatic Deposits.

The working of the phosphate of lime since its commencement, about nine years ago, proves clearly how easily and cheap this mineral can be sent to market. Pick and shovel are the only tools needed. After the upper part, generally mixed

with many small roots and fibers to a depth of two or three inches, has been removed, the disintegrated mineral appears in form of roundish grains, wanting only to be loosened somewhat with the pick to facilitate the shoveling. Most of the openings, as stated already, increase in size, frequently to a considerable extent, a single one yielding many tons of phosphate; a circumstance that makes it very difficult to arrive at an exact estimate of the quantity of the fine phosphate contained in them. The only feasible plan was, therefore, to ascertain what area had been worked near Lulu Bay, on the lower flat. We found that from $1\frac{1}{2}$ acres, one thousand six hundred and thirty-five tons had been shipped to a house in Camden, N. J., and that there yet remained two large piles at the landing ready for shipment, containing at the lowest estimate five hundred tons, making two thousand one hundred and thirty-five tons, although it had not been worked with that care and economy which the value of it demanded.

The island possesses an area of somewhat over 11 square miles, and deducting from it one-half as occupied by carbonate of lime, it leaves $5\frac{1}{2}$ square miles which are covered with the phosphate. Taking only 5 miles into consideration, the same, according to the above statement, will yield four million five hundred and fifty-four thousand six hundred and sixty-six tons of the fine variety of phosphate. That this estimate is correct is further proved by the quantity worked out from not quite 40 acres on the upper flat, and from which forty-five thousand tons were obtained, of which about five thousand tons lay near the landing waiting shipment.

Among the fine-grained phosphate is found a great many loose lumps, and in working lower down in most of the nests, this mineral assumes a hard rocky nature.

I have stated already that the hard phosphate is visible on the surface at a great many places; should it prove by analysis to be good, then it can be said, without the least exaggeration, that this mineral is indeed inexhaustible.

The cost of digging and wheeling a ton of the disintegrated phosphate, I estimate at one dollar. This work can be lessened, and consequently made cheaper, by laying railroad tracks, the construction of which, on account of the level nature of the flats, could be put down at a small cost, especially if the rail

is laid on wooden tracks. The two shutes, from which the boats are loaded, will be sufficient for a long series of years: and as pretty near all other accommodations, such as houses for the hands, for storing provisions, for catching rain water in cisterns, are put up, the working capital need not be large.

In conclusion, I wish to remark, that the harbor of Navassa is an ordinary trade wind harbor, but being sheltered by the adjacent mountainous islands of St. Domingo and Cuba from heavy gales and seas, is much improved thereby. There are no reefs or shoals near the island that would make shipping dangerous, and vessels can haul close along side of the cliffs, if they wish to do so, as the depth of water all around the island is twelve fathoms, and the same depth for a mile or more from it, with but little variation. The facilities for loading vessels are therefore very superior. Owing to the cliffs being about forty feet perpendicular, the phosphate can be shuted down in boats and launches. One hundred tons a day are frequently put on board of one vessel with only thirty or forty men and two boats.

Taking into consideration the immense quantity of phosphate deposited on your island, the great ease for digging and loading, the short distance to a market, the giving out of the phosphatic guanoes of the Caribbean sea, the scarcity of it in nature, and the great demand, which will be almost unlimited, for the manufacture of super-phosphate, it cannot fail but that Navassa must become the main source from which this mineral can be supplied.

Wishing you all success,

I remain,

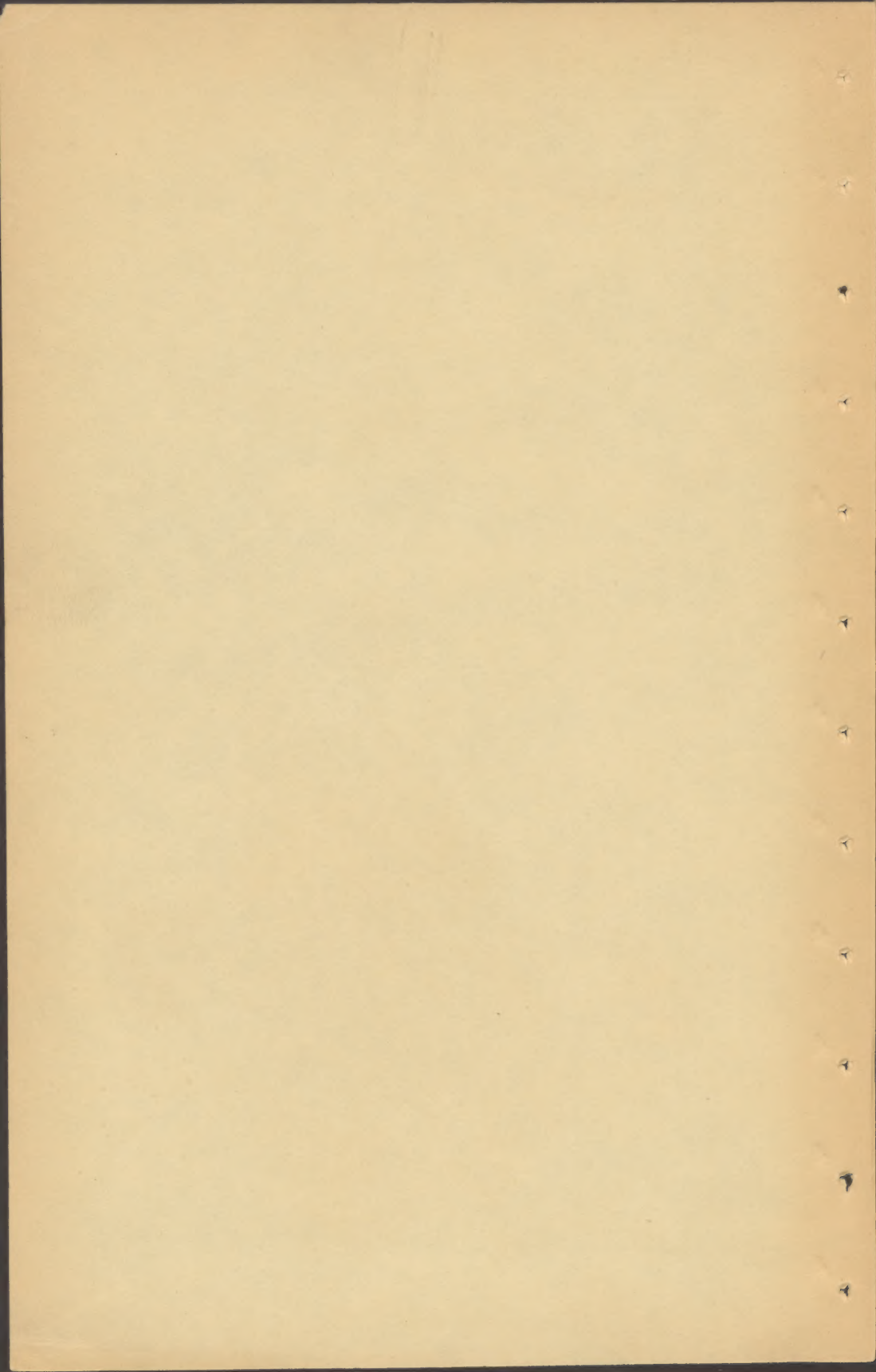
Very respectfully, yours,

AUGUSTUS H. FICK,

Mining Engineer.

BALTIMORE:
PRINTED BY J. B. ROSE & CO.
5 South Calvert Street.

NAVASSA.



JUL 29 1939

